Human Health and Environmental Effects of Emissions from Power Generation

Power generation is a significant source of pollutants that can impair human health and the environment, including sulfur dioxide (SO_2), nitrogen oxide (NOx), and mercury. The Clean Air Act has been successful in reducing these emissions, but power generation still contributes approximately 70% of SO_2, 20% of NOx, and 40% of mercury emissions into the environment. These emissions from power generation contribute to a range of human health and environmental problems, and interstate and long range transport of emissions continue to play significant roles in these problems. Cap and trade programs benefit human health and the environment and address transport by significantly reducing emissions over large geographic areas.

When emitted into the atmosphere, SO_2 and NOx react with water and other compounds to form various acidic compounds, fine particles, and ozone. These pollutants can remain in the air for days or even years. Prevailing winds can transport them hundreds of miles, often across state and national borders. The pollutants then fall to the earth in either a wet form (rain, snow, and fog) or a dry form (gases and particles). Impacts include impaired air quality; damage to public health; degradation of visibility; acidification of lakes and streams; harm to sensitive forest and coastal ecosystems; and accelerated decay of materials, paints, and cultural artifacts such as buildings, statues, and sculptures nationwide.

Emissions from power generation contribute to a range of human health and environmental concerns.

Mercury, a product of coal-burning, can be deposited locally or it can be transported through the atmosphere for days to years before being deposited into water bodies. Once mercury reaches lakes, rivers and oceans, it can be transformed into methylmercury and bioaccumulate in the food chain. This results in predatory fish and fish-eating birds and mammals accumulating mercury concentrations millions of times higher than what is found in the water or air.

How Do Power Plant Emissions Impact Human Health?

SO_2 and NOx emissions form fine particles in the atmosphere. Particulate matter is the term used for a mixture of solid particles and liquid droplets found in the air; fine particles ($PM_{2.5}$) are smaller than 2.5 microns (millionths of a meter) in diameter. Power plants emit particles directly into the air, but their major contribution to particulate matter air pollution is emissions of SO_2 and NOx, which are converted into sulfate and nitrate particles in the atmosphere. These particles make up a large proportion of the fine particle pollution in most parts of the country. A substantial body of published scientific literature recognizes a correlation between elevated fine particulate matter and increased incidence of illness and premature mortality. The health effects of $PM_{2.5}$ include:

- Increased incidence of premature death, primarily in the elderly and those with heart or lung disease;
- Aggravation of respiratory and cardiovascular illness, leading to hospitalizations and emergency room visits for children and individuals with heart or lung disease;
- Decreased lung function and symptomatic effects, including acute bronchitis, particularly in children and asthmatics;
- New cases of chronic bronchitis;
- Increased work loss days, school absences, and emergency room visits.

NOx emissions react in the atmosphere to form ozone. NOx and volatile organic compounds react in the atmosphere in the presence of sunlight to form ground-level ozone. Ground-level ozone is a major component of smog in our cities and in many rural areas as well. Though naturally occurring ozone in the stratosphere provides a protective layer high above the earth, the ozone that we breathe at ground level has been linked to respiratory illness and other health problems, including:

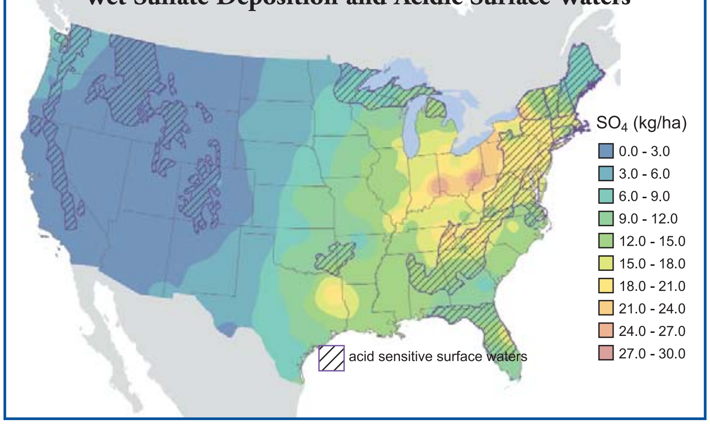
- Decreases in lung function, resulting in difficulty breathing, shortness of breath, and other symptoms;
- Respiratory symptoms, including bronchitis, aggravated coughing, and chest pain;
- Increased incidence/severity of respiratory problems (e.g. aggravation of asthma, susceptibility to respiratory infection) resulting in more hospital admissions and emergency room visits;
- Chronic inflammation and irreversible structural changes in the lungs, that, with repeated exposure, can lead to premature aging of the lungs and other respiratory illness.

Mercury emissions are deposited in watersheds and transformed into methylmercury, which contaminates fish. In the U.S., human exposure to mercury is primarily the result of consumption of fish contaminated with methylmercury. Other fish-eating mammals and birds are also exposed in this manner. The primary symptoms of mercury exposure are neurological, including brain damage, lack of motor skills, impaired cognitive skills, and difficulty speaking and hearing. These effects are most pronounced on those exposed during the development of the nervous system, such as fetuses and young children. Forty-four states have advisories warning the public to restrict eating fish from their lakes, rivers, streams, and/or coastal waters due to methylmercury. EPA estimates that 12 million acres of lakes and 475,000 miles of rivers, as well as the coastal waters of 11 states, are impaired by mercury.

How Do Power Plant Emissions Impact the Environment?

SO_2 and NOx emissions react in the atmosphere to form acidic compounds that harm lakes and streams. When the acidic compounds that are formed as a result of SO_2 and NOx emissions are deposited to the earth's surface, they can acidify lakes and streams. Acidification (low pH) and the chemical changes that result, including higher aluminum levels, make it difficult for some fish and other aquatic species to survive, grow, and reproduce. In the 1980s, acid rain was found to be the dominant cause of acidification in 75% of acidic lakes and 50% of acidic streams. Areas especially sensitive to acidification include portions of the Northeast (particularly the Adirondack and Catskill Mountains, portions of New England, and streams in the mid-Appalachian highlands) and Southeastern streams. Today in the Adirondack Mountains, Appalachian plateau, and upper Midwest regions, there are 25-30% fewer chronically acidic lakes and streams than in the early 1990s, although these waterbodies remain sensitive to acid rain. Lakes and streams in New England and the Southeast showed little decrease in acidification throughout the 1990s.

Wet Sulfate Deposition and Acidic Surface Waters



Wet Sulfate deposition is highest in many acid sensitive regions. Source: National Atmospheric Deposition Program.

Acid deposition harms forests and trees. Acid rain can harm forest ecosystems by directly damaging plant tissues. One of the best examples of direct damage involves the leaching of nutrients from the needles of red spruce, which reduces the ability of the trees to tolerate cold winter temperatures and has contributed to the decline of red spruce forests throughout the mountains of the eastern U.S. In other cases, acid rain can combine with other pollutants, such as ozone, to weaken trees and make them vulnerable to threats such as pests, which cause mortality. Acid deposition can also affect forest ecosystems indirectly by changing the chemistry of forest soils, including the leaching of plant nutrients from soils. It can also elevate levels of aluminum in soil water, which impairs the ability of trees to use soil nutrients and can be directly toxic to plant roots.

Nitrogen deposition contributes to impaired coastal water quality. Nitrogen deposited from the atmosphere is a substantial source of nitrogen in many estuaries and coastal waters. Large amounts of nitrogen in estuaries and coastal waters can have significant ecological impacts, including massive die-offs of estuarine and marine plants and animals, loss of biological diversity, and degradation of essential coastal ecosystem habitat such as seagrass beds. For many species of fish and shellfish, these seagrass beds are essential nurseries and places to escape from predators. Excessive amounts of nitrogen in coastal waters from atmospheric deposition are thought to be a contributor to harmful algal blooms, such as red tides, that kill millions of fish each year and can be toxic to humans as well.

Fine particles impair visibility and increase regional haze. Fine particles formed in the atmosphere by the conversion of SO_2 and NOx emissions scatter light and create hazy conditions, decreasing visibility and contributing to regional haze. Visibility impairment spoils scenic vistas across broad regions of the country, including in many National Parks and wilderness areas. Regional haze is also responsible for impaired urban vistas nationwide. In the western U.S., the level of visibility impairment for the worst days remained unchanged through the 1990s. Visibility in the eastern U.S. improved in some areas during the 1990s, but remains significantly impaired overall.

Acid deposition and particles damage materials and cultural resources. A significant number of properties of aesthetic and historical value in the United States, including monuments, buildings, and statues, are potentially at risk for damage from air pollution. Structures made of limestone and marble are particularly sensitive to acid deposition. Acid particles and deposition increase the rate of weathering for these materials, eventually resulting in aesthetic and/or structural damage.

Comparison of Poor and Good Visibility

Modeled visibility conditions on the National Mall, Washington, D.C. Left image: poor visibility, 5 mile visual range. Right image: clear day, 90 mile visual range.